UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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A METHOD FOR ESTIMATING THE RATE OF SOIL LOSS BY SHEET EROSION FROM INDIVIDUAL FIELDS OR FARMS UNDER VARIOUS TYPES OF LAND TREATMENT

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TABLE OF CONTENTS

Introduction 1

The Method 1

Application 2

Suggested Uses 3

Example of Use 3

Acknowledgements 4

Bar Graph 5

Tables 1 . . . . . 6 & 7

2 8

3 9

4 10

5 11

6 12

A METHOD FOR ESTIMATING THE RATE OF SOIL LOSS BY SHEET EROSION FROM INDIVIDUAL FIELDS OR FARMS UNDER VARIOUS TYPES OF LAND TREATMENT

Introduction

This method is based on the relationship between rate of erosion and (1) soil characteristics, (2) slope of land in percent, (3) slope length, in feet, (4) vegetative cover and (5) the maximum 30-minute rainfall to be expected once in 2 years. 1/

Soil unit, slope in percent and maximum 30-minute rainfall (2-year frequency) are erosion factors which are not subject to modification by the farm or ranch operator. However, slope length and vegetative cover and their effect on rate of soil loss can be varied. It is through these latter two avenues that a major reduction in sheet erosion is possible.

The Method

With one exception, the basic data needed to calculate gross sheet erosion by this method may be obtained from the soil survey and conservation plan map of the field or farm involved. Slope length must be measured either on the soil survey map or on the ground. Length of slope, as used here, is the total uninterrupted distance overland flow must travel before reaching a well-defined gully or natural drainageway. Fence rows across the slope have been considered as slope length breaks. In some cases slope length may not be confined entirely to the farm or field involved. The uninterrupted distance surface flow travels may include the distance such flow travels across a neighboring area.

1/ G. W. Musgrave, Soil Conservation Service, Research, "The Quantitative Evaluation of Factors in Water Erosion-A first Approximation," Journal of Soil and Water Conservation, Volume 2, No. 3, July, 1947.

Delineate land use on the soil survey map. For cultivated land show row crops, small grains, cover crops and other types of crops such as cultivated hay or pasture. Indicate terraced fields by standard symbol. Measure and average the slope lengths by soil units and slope classes. Slope lengths for terraced fields will be the average distance between terraces. Measure acres in each field crop by soil unit, percent slope and slope length. Combine all like delineations and tabulate data in columns 1 through 10 on table 6. Show the acres of pasture land with excellent, good, fair or poor cover by soil unit, percent slope and slope length, and tabulate as for cultivated land.

Application

As an example assume a farm of 180 acres located in Ellis County, Texas. The land use consists of 80 acres of cultivated land and 100 acres of native pasture. The soil unit is 2, average slope is 3 percent and the average slope length is 300 feet. Present cropping pattern is 100 percent row crop, or 80 acres with no treatment. Present condition of the 100 acres of native pasture is poor. Using the above data on cultivated land fill in column 1 through 10, line 1, table 6. From table 1 the basic erosion rate of soil unit 2 is 0.54 inches annually (column 11). (Note: The basic erosion rates of table 1 are based on 100 percent row crop cover, 10 percent slope, 72 feet slope length and a P_{30} rainfall of 1.375", 2-year frequency.) Tables 2, 3, 4 and 5 are used to adjust for any change from the above conditions. From table 2 the adjustment factor for 3 percent slope and 300 feet slope length is .313 (column 12). From table 3 the adjustment factor for 100 percent row crop is 1.0 (column 13).

From table 4, the P_{30} rainfall for Ellis County is 1.500 inches which corresponds to the adjustment factor 1.115 (column 14). The product of the figures in columns 11 through 14 equals the average annual soil loss in inches per acre or 0.188 (column 15). The rate of soil loss for other crop rotations and conservation practices for cultivated land are calculated in a like manner.

For native pasture or woods, repeat the same procedure.

Column 16, table 6 is self-explanatory.

Suggested Uses

(1) Training Soil Conservation Service personnel.

(2) For use on the land with cooperators to calculate the soil losses caused by sheet erosion for various combinations of soil conservation practices.

(3) Aid in explaining why upland watersheds need conservation treatment.

(4) Group meetings.

(5) Tours.

(6) Other uses.

Example of Use

(1) Explain that you would like to assist cooperator in determining the soil loss on one or more of "his" fields. (Should include at least one cultivated field and one pasture.)

(2) Let cooperator select fields. This step is a must.

(3) Measure average thickness of topsoil by use of spade or sharpshooter. Several measurements should be made at points selected

by the cooperator. If possible, measure topsoil depth on at least one virgin profile for comparison with average topsoil depth on eroded profiles. (Encourage cooperator to participate. Get him interested. Point out that thickness of topsoil is usually a major factor in crop yields.)

(4) Determine soil unit during step 3.

(5) Measure percent of slope. Several measurements should be made to determine an average. The percent of slope can be measured with hand level or string level.

(6) The length of slope is measured by pacing, chaining or by scaling on a photograph.

(7) Calculate annual soil loss in inches for existing land use, rotations and other applied soil conservation practices.

(8) Calculate annual soil loss for several combinations of rotations and/or soil conservation practices. (Calculations required in steps 7 and 8 may be made by use of attached nomograph.)

(9) Draw a bar chart showing the relative soil loss for various combinations of rotations and soil conservation practices. (See Figure 1.)

Acknowledgements

Credit is hereby given to those fellow workers whose help made this paper possible. The writers are particularly indebted to the following personnel of the Soil Conservation Service: R. M. Marshall, Acting Assistant Regional Director, Soil Survey; P. M. Price, Soil Conservationist, Regional Water Conservation Planning Division; H. M. Kautz, Acting Chief, Regional Water Conservation Planning Division and Howard Matson, Acting Assistant Regional Director, Engineering and Planning, all of Fort Worth, Texas, for review, comments and many helpful suggestions.

Figure I

COMPARISON BETWEEN PRESENT TOPSOIL DEPTH AND ESTIMATED TOPSOIL DEPTH IN 20 YEARS UNDER FOUR TREATMENT PLANS

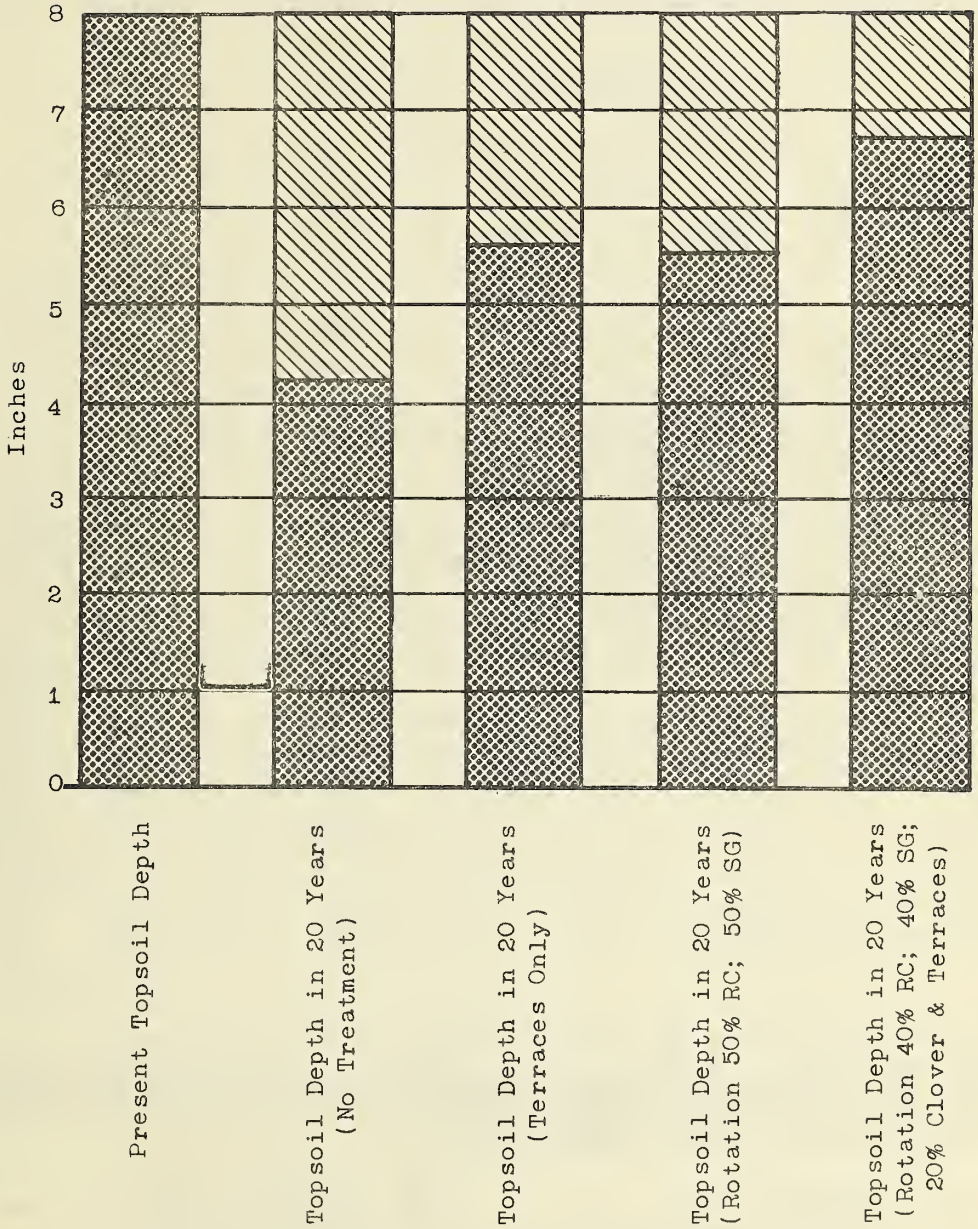


Table No. 1
Basic Erosion Rates by Soil Units 1/
Region 4, Soil Conservation Service

Soil Units **	Inches Annual Soil Loss	Soil Units	Inches Annual Soil Loss
1	.65	12	.15
1	.54 in D1 & D2 *	12X	.12
2	.54	13	.12
2X	.41	14	.29
2Xd	.08	15	.12
3	.65	16	.65
4	.54	17	.54
4H	.54	18	.41
4X	.41	18	.65 in D5*
5	.65	19	.65
5a	.65	19a	.65
6	.41	20	.41
6	.65 in A1 & A2*	20d	.15
6	.54 in D3,D4 & D5*	23	.41
6d	.29	24	.54
7	.29	24	.65 in A3*
7	.41 in B1, B2 & D5*	24c	.08
7	.65 in A1, & A2 *	24d	.41
7d	.15	25	.41
7f	.15	25	.65 in A1, A2* & A3*
7X	.15	25c	.08
7Xd	.08	25d	.08
8	.41	26	.08
9	.29	27	.08
10	.29	27	.65 in A1 & A2*
11	.29	28	.08
		28	.65 in D3 & D4*

1/ Source of Data - Table III, Soil Conservation Surveys Division Memo on Conservation Time Table Study, dated 26 April, 1949 to State Soil Scientists and Survey Supervisors.

* A-1 - Loessial hills
A-2 - Loessial terraces
A-3 - Forested Coastal Plain
B-1 - Ozark highland
B-2 - Quachita highland
D-1 - Western foothills mesa land
D-2 - High plains
D-3 - Rolling Red Plains
D-4 - Reddish Prairie
D-5 - Cross timbers

** Standard definitions as outlined. Soil Conservation Survey Memo 6, Rev.

Descriptions of the soil units:

1 - Deep, fine textured, very slowly permeable soils
2 - Deep, fine textured, slowly permeable soils
2X - Deep, fine textured, moderately permeable soils
3 - Deep, fine textured, very slowly permeable bottomland soils
4 - Deep, fine textured, slowly permeable bottomland soils
4X - Deep, fine textured, moderately permeable bottomland soils
5 - Deep, medium textured, very slowly permeable soils
6 - Deep, medium textured, slowly permeable soils
7 - Deep, medium textured, moderately permeable soils
7X - Deep, medium textured, rapidly permeable soils
8 - Deep, medium textured, slowly permeable bottomland soils
9 - Deep, medium textured, moderately permeable bottomland soils
10 - Deep, coarse textured, very slowly permeable soils
11 - Deep, coarse textured, slowly permeable soils
12 - Deep, coarse textured, moderately permeable soils
12X - Deep, coarse textured, moderately rapidly permeable soils
13 - Deep, coarse textured, rapidly permeable soils
14 - Deep, coarse textured, slowly permeable bottomland soils
15 - Deep, coarse textured moderately permeable bottomland soils
15X - Deep, coarse textured, rapidly permeable bottomland soils
16 - Shallow, fine textured, very slowly permeable soils
17 - Shallow, fine textured, slowly permeable soils
18 - Shallow, fine textured, moderately permeable soils
19 - Shallow, medium textured, very slowly or slowly permeable soils
20 - Shallow, medium textured, moderately permeable or rapidly permeable soils
21 - Shallow, coarse textured, slowly permeable soils
22 - Shallow, coarse textured, moderately permeable soils
23 - Shallow, coarse textured, rapidly permeable soils
24 - Very shallow, fine textured soils
25 - Very shallow, medium textured soils
26 - Very shallow, coarse textured soils
27 - Rough broken or rough stony land, non-calcareous materials
28 - Rough broken or rough stony land, calcareous materials
29 - Organic soils (peat and muck)
30 - Mixed, very shallow, shallow and deep sandy lands
31 - Mixed, very shallow, shallow and deep heavy lands
32 - Not used
33 - Non-arable, alluvial soils, undifferentiated

a. Moderately wet soils.
c. Stony soils.
d. Cherty or gravelly soils.
f. High lime soils.

Table No. 2. Adjustment Factors for Slope Percent and Slope Length (100% Row Crop Cover) (P_{30} = 1.375") Basic Soil Erosion Rate = 1.0"

Percent Slope	Slope Length Feet																								
	40	50	60	72.6	80	90	100	120	140	160	180	200	220	240	260	280	300	350	400	500	600	700	800	900	1000
.5	.015	.016	.017	.019	.019	.020	.021	.022	.024	.025	.026	.027	.028	.029	.029	.030	.031	.032	.034	.037	.039	.042	.044	.046	.048
1.	.036	.039	.042	.045	.046	.048	.050	.053	.056	.059	.061	.063	.066	.068	.070	.072	.073	.077	.081	.089	.094	.099	.104	.109	.113
2.	.092	.100	.107	.115	.118	.124	.128	.137	.145	.150	.157	.162	.170	.173	.178	.184	.187	.197	.207	.228	.239	.253	.266	.278	.289
3.	.153	.167	.178	.192	.197	.207	.215	.228	.242	.251	.263	.270	.284	.290	.297	.307	.313	.330	.345	.380	.399	.422	.443	.465	.482
4.	.228	.248	.265	.285	.293	.308	.319	.339	.359	.373	.390	.402	.422	.430	.442	.456	.464	.490	.513	.564	.593	.627	.658	.690	.715
5.	.309	.336	.359	.378	.386	.417	.432	.459	.486	.506	.529	.544	.571	.582	.598	.618	.629	.664	.695	.764	.803	.849	.892	.934	.969
6.	.398	.432	.462	.497	.512	.537	.557	.591	.626	.651	.681	.701	.735	.750	.770	.795	.810	.855	.895	.984	1.034	1.093	1.148	1.203	1.247
7.	.489	.531	.568	.611	.629	.660	.684	.727	.770	.800	.837	.861	.904	.923	.947	.977	.996	1.051	1.100	1.210	1.271	1.344	1.411	1.479	1.534
8.	.585	.636	.680	.731	.753	.789	.819	.870	.921	.957	1.001	1.031	1.082	1.104	1.133	1.169	1.191	1.257	1.316	1.447	1.520	1.608	1.689	1.769	1.835
9.	.683	.743	.794	.854	.879	.922	.956	1.016	1.102	1.136	1.170	1.204	1.264	1.289	1.324	1.366	1.392	1.469	1.537	1.691	1.776	1.879	1.973	2.067	2.143
10.	.800	.870	.930	1.000	1.030	1.080	1.120	1.190	1.260	1.310	1.370	1.410	1.480	1.510	1.550	1.600	1.630	1.720	1.800	1.980	2.080	2.200	2.310	2.420	2.510
11.	.898	.977	1.044	1.123	1.157	1.213	1.258	1.336	1.415	1.471	1.538	1.583	1.662	1.696	1.741	1.797	1.830	1.931	2.021	2.223	2.336	2.471	2.594	2.718	2.819
12.	1.009	1.098	1.174	1.262	1.300	1.363	1.413	1.502	1.590	1.653	1.729	1.779	1.868	1.906	1.956	2.019	2.057	2.171	2.272	2.499	2.625	2.776	2.915	3.054	3.168
13.	1.132	1.231	1.316	1.415	1.457	1.528	1.585	1.684	1.783	1.854	1.938	1.995													
14.	1.255	1.365	1.459	1.569	1.616	1.694	1.757	1.867	1.977	2.055	2.149	2.212													
15.	1.378	1.499	1.602	1.723	1.775	1.861	1.930	2.050	2.171	2.257	2.360	2.429													

Data in Table 2 - Based on Logarithmic curve developed from data by G. W. Musgrave, SCS Research, Published in Journal of Soil and Water Conservation Vol. 2, No. 3, July, 1947. Title of Article - "The Quantitative Evaluation of Factors in Water Erosion - A First Approximation."

Note: Data in Table 2 applies to soils having a basic erosion rate of 1.0 inch annually. Rates for soils having other basic erosion rates are determined by multiplying data in Table 2 by the applicable basic erosion rate from Table 1.

Table No. 3 1/
Land Use Adjustment - Cropland
(All Areas Except R-1; B-2 and B3)

Based on Following Relative Erosion Rates: Row Crop 1.00
Small Grair .30
Hay-Pasture .10

Percent Small Grains - Fall Planted (Read down)

Row Crop Percent	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	.10	.11	.12	.13	.14	.15	.16	.17	.18	.19	.20	.21	.22	.23	.24	.25	.26	.27	.28	.29	.30
5	.15	.16	.17	.18	.19	.20	.21	.22	.23	.24	.25	.26	.27	.28	.29	.30	.31	.32	.33	.34	
10	.19	.20	.21	.22	.23	.24	.25	.26	.27	.28	.29	.30	.31	.32	.33	.34	.35	.36	.37		
15	.24	.25	.26	.27	.28	.29	.30	.31	.32	.33	.34	.35	.36	.37	.38	.39	.40	.41		1.00	100
20	.28	.29	.30	.31	.32	.33	.34	.35	.36	.37	.38	.39	.40	.41	.42	.43	.44		.98	.96	95
25	.33	.34	.35	.36	.37	.38	.39	.40	.41	.42	.43	.44	.45	.46	.47	.48		.94	.93	.91	90
30	.37	.38	.39	.40	.41	.42	.43	.44	.45	.46	.47	.48	.49	.50	.51		.92	.90	.89	.87	85
35	.42	.43	.44	.45	.46	.47	.48	.49	.50	.51	.52	.53	.54	.55		.88	.87	.85	.84	.82	80
40	.46	.47	.48	.49	.50	.51	.52	.53	.54	.55	.56	.57	.58		.86	.84	.83	.81	.80	.78	75
45	.51	.52	.53	.54	.55	.56	.57	.58	.59	.60	.61	.62		.82	.81	.79	.78	.76	.75	.73	70
50	.55	.56	.57	.58	.59	.60	.61	.62	.63	.64	.65		.79	.78	.77	.75	.74	.72	.71	.69	65
55	.60	.61	.62	.63	.64	.65	.66	.67	.68	.69		.76	.75	.73	.72	.70	.69	.67	.66	.64	60
60	.64	.65	.66	.67	.68	.69	.70	.71	.72		.74	.72	.71	.69	.68	.66	.65	.63	.62	.60	55
65	.69	.70	.71	.72	.73	.74	.75	.76		.70	.69	.67	.66	.64	.63	.61	.60	.58	.57	.55	50
70	.73	.74	.75	.76	.77	.78	.79		.68	.66	.65	.63	.61	.60	.59	.57	.56	.54	.53	.51	45
75	.78	.79	.80	.81	.82	.83		.64	.63	.61	.60	.58	.57	.55	.54	.52	.51	.49	.48	.46	40
80	.82	.83	.84	.85	.86		.61	.60	.59	.57	.56	.54	.53	.51	.50	.48	.47	.45	.44	.42	35
85	.87	.88	.89	.90		.58	.57	.55	.54	.52	.51	.49	.48	.46	.45	.43	.42	.40	.39	.37	30
90	.91	.92	.93		.56	.54	.53	.51	.50	.48	.47	.45	.44	.42	.41	.39	.38	.36	.35	.33	25
95	.96	.97		.52	.51	.49	.48	.46	.45	.43	.42	.40	.39	.37	.36	.34	.33	.31	.30	.28	20
100	1.00		.50	.48	.47	.45	.44	.42	.41	.39	.38	.36	.35	.33	.32	.30	.29	.27	.26	.24	15
		.46	.45	.43	.42	.40	.39	.37	.36	.34	.33	.31	.30	.28	.27	.25	.24	.22	.21	.19	10
	.44	.42	.41	.39	.38	.36	.35	.33	.32	.30	.29	.27	.26	.24	.23	.21	.20	.18	.17	.15	5
.40	.39	.37	.36	.34	.33	.31	.30	.28	.27	.25	.24	.22	.21	.19	.18	.16	.15	.13	.12	.10	0
100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0	% Row Crop

Percent Small Grains (Spring Planted) Read Up

Based on Following Relative Erosion Rates - Row Crop = 1.00; Small Grains = .40; Hay & Pasture = .10

1/ Source of Data: Time Table Study Regional Project Plans Division - Table III, June 17, 1949.

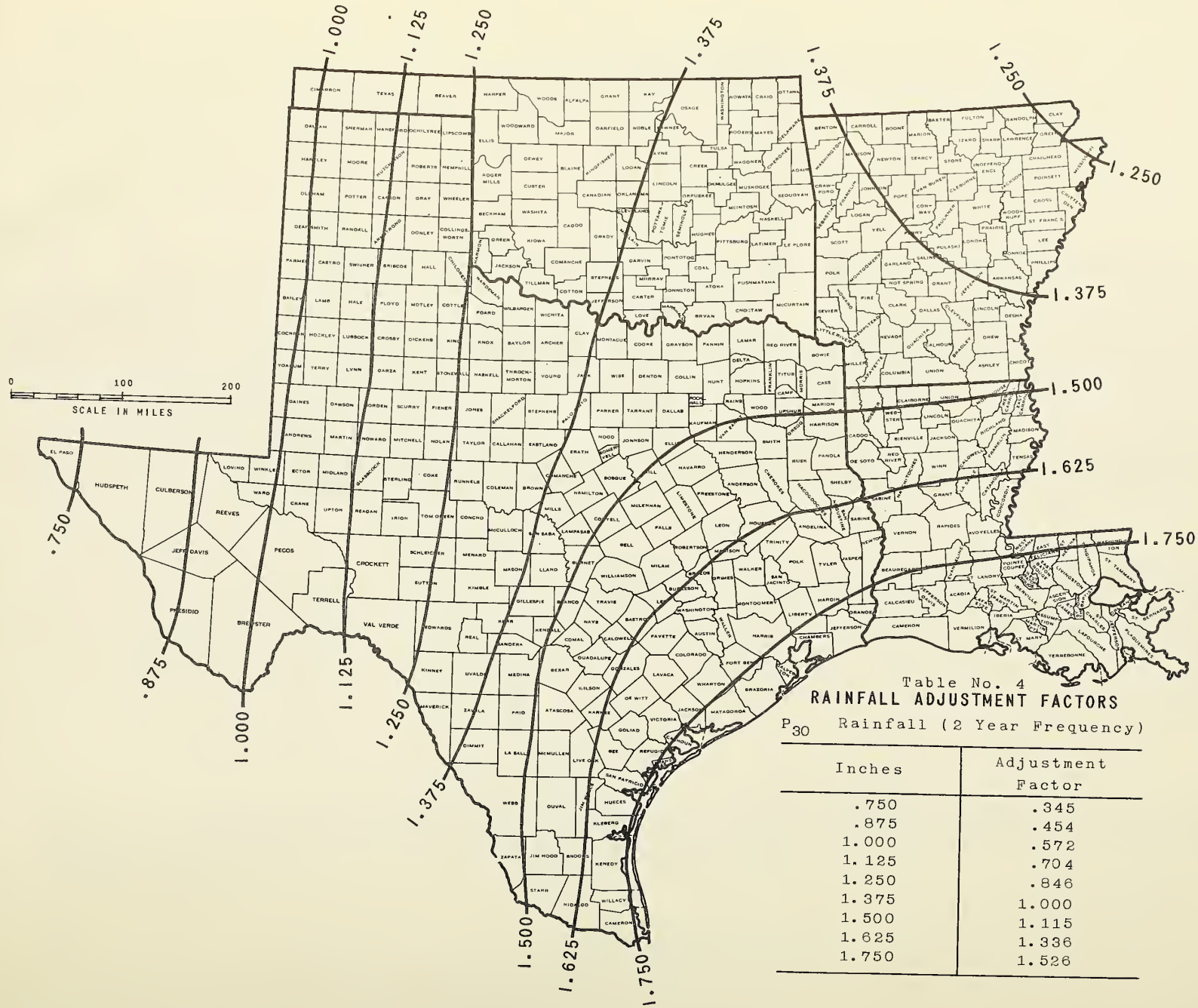


Table No. 4

RAINFALL ADJUSTMENT FACTORS

P_{30} Rainfall (2 Year Frequency)

Inches	Adjustment Factor
.750	.345
.875	.454
1.000	.572
1.125	.704
1.250	.846
1.375	1.000
1.500	1.115
1.625	1.336
1.750	1.526

Table No. 5

Relative Rates of Erosion Under Various Types of Cover and Cover Conditions.

Type and Cover Condition	Percent of Row Crop Erosion Rate
Row Crop	100 1/
Small Grains (Fall Planted)	30 1/
Small Grains (Spring Planted)	40 1/
Rotation Hay and Pasture	10 1/
Pasture Excellent Cover	1 2/
Pasture Good Cover	10 2/
Pasture Fair Cover	20 2/
Pasture Poor Cover	30 2/
Pasture Very Poor Cover (Stomp Lots, etc.)	50 2/
Woods Poor Cover	15 1/
Woods Fair Cover	10 1/
Woods Good Cover	0 1/

Reference:

1/ Time Table Study, June, 1949

2/ Estimated by writers.

COVER DENSITY GUIDE

Cover Condition	Ground Cover Including Litter (%)
Excellent	90 - 100
Good	70 - 89
Fair	50 - 69
Poor	30 - 49
Very Poor	15 - 29

Table No. 6

Farm Sheet Erosion Data

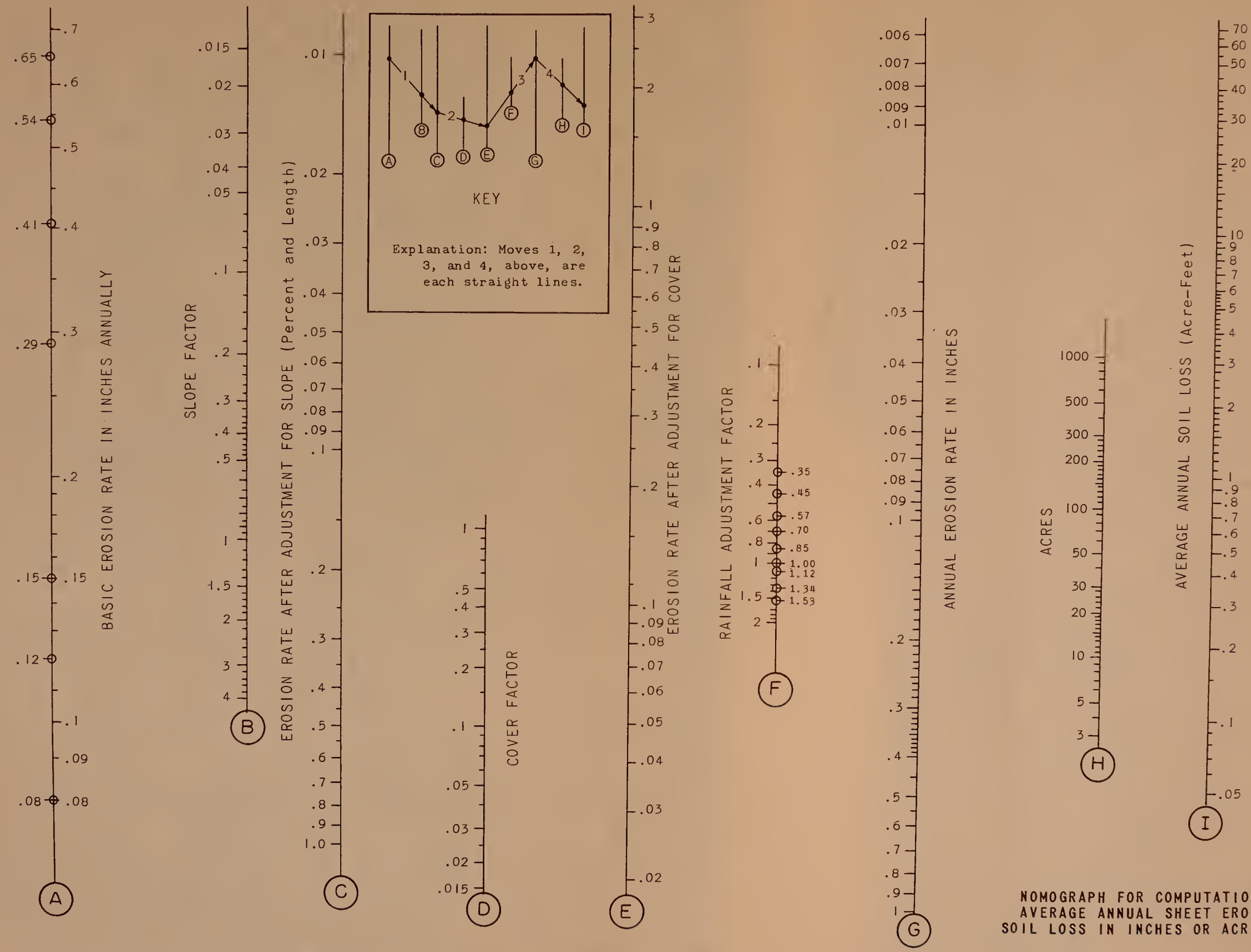
Cooperator: John Doe SCD: Ellis Prairie County: Ellis Planner: R. Roe Date: 12-7-53

Problem Area: Blackland Prairies.

Field or Pasture No.	Acres	Type of Treatment	Soil Unit	Slope		Land Use: Cultivated			Pasture or Woods (Av.Cover Conditions)	Basic Erosion Rate by Soil Unit (From Table 1) (Inches)	Adjustment Factors			Av. Annual Soil Loss (Product of Col.11; 12; 13 & 14). (Inches)	Average Annual Soil Loss Rate TREATED VS. UNTREATED (Percent)
				Percent	Length 1/ (Ft.)	Row Crops (%)	(F)Fall Planted (S)Spg. Planted (%)	Hay or Pasture Crops (%)			Slope From Table 2	Cover (Table 3 Cult.) (Table 5 Pasture or Woods)	P_{30} Rainfall (Table 4)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
F-1	80	None	2	3	300	100	0	0	-	.54	.313	1.00	1.115	.188	100.0
F-1	80	Terraced	2	3	80	100	0	0	-	.54	.197	1.00	1.115	.118	62.8
F-1	80	Rotation	2	3	300	50	(F) 50	0	-	.54	.313	.65	1.115	.123	65.4
F-1	80	Rotation & Terraces	2	3	80	50	(F) 50	0	-	.54	.197	.65	1.115	.077	40.9
F-1	80	Rotation	2	3	300	40	(F) 40	20 Clover	-	.54	.313	.54	1.115	.101	53.7
F-1	80	Rotation & Terraces	2	3	80	40	(F) 40	20 Clover	-	.54	.197	.54	1.115	.064	34.0
P-2	100	None	2	3	300	-	-	-	Poor	.54	.313	.30	1.115	.057	100.0
P-2	100	2/	2	3	300	-	-	-	Fair	.54	.313	.20	1.115	.038	66.7
P-2	100	2/	2	3	300	-	-	-	Good	.54	.313	.10	1.115	.019	33.3
P-2	100	2/	2	3	300	-	-	-	Exoellent	.54	.313	.01	1.115	.002	3.5

1/ Slope length on terraced land corresponds to the average distance between terraces.
2/ Local range practices to achieve desired cover density.

Note: Table No. 6 will serve as a work sheet for recording basic data and calculating sheet erosion rates.



NOMOGRAPH FOR COMPUTATION OF AVERAGE ANNUAL SHEET EROSION SOIL LOSS IN INCHES OR ACRE-FEET

Basic data assembled by: Leland H. Barnes and Sam B. Maner. Drawn by: Glenn G. Commons December 1953

3-8-54

4-N 8961

Agr-SCS-Ft. Worth, Tex., 1954